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(54) **Reconfigurable satellite with modifiable antenna coverage and communications backup capabilities**

Umkonfigurierbarer Satellit mit veränderbarer Antennenbedeckung und Kommunikations-Überlagerungsfähigkeiten

Satellite reconfigurable ayant une couverture d'antenne modifiable et des possibilités de sauvegarde de communications

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EP-A- 0 845 833 **EP-A- 0 854 590**
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Description

[0001] This application is related to European Patent EP 1 014 483 B1 entitled "A Rotatable Scannable Reconfigurable Shaped Reflector With a Movable Feed System".

[0002] The present invention relates to space and communications satellites, and more particularly, to a reconfigurable payload for a satellite so that it may mimic many payloads to provide backup services for many different satellites or to be used as a flexible stand alone satellite.

[0003] Satellite fleet operators depend on continuity of service for a satellite in order to maintain continuous service to satellite users. In the event of a satellite failure, a backup service is needed to avoid extended inconvenience to users, or to avoid the risk of users being lost to a competitor before a backup satellite can be ordered, built and launched.

[0004] In many applications, a satellite's frequency plan and coverage is unique. In some cases, the satellite customer does not have prior knowledge of his customers. Therefore, a reconfigurable satellite provides in-orbit flexibility. If a customer base changes while the satellite is in orbit, it can be reconfigured to provide service. In the situation of providing backup services, a unique spare satellite would be required for each satellite in a fleet of satellites.

[0005] A backup satellite having the capability to be reconfigured would avoid the expensive option of a unique spare. A satellite having a communication payload that can be reconfigured in space so that it mimics various payloads with various frequency plans and antenna coverages would allow a single satellite to provide backup services to many different satellites. In addition, a reconfigurable payload would allow a satellite fleet operator to provide a replacement satellite relatively quickly in the event of a satellite failure.

[0006] A satellite having a communication payload that can be reconfigured in space so that it mimics various payloads with various frequency plans and antenna coverages would allow a single satellite to provide services to many different customers over the lifetime of the satellite. A reconfigurable payload would allow a satellite fleet operator to have flexibility in-orbit. This allow the operator to procure and build a reconfigurable satellite while marketing satellites to various customers. The result is a satellite that is ready for orbit quicker, and ready to provide services sooner.

[0007] EP 0 845 833 entitled "On-orbit reconfigurability of a shaped reflector with feed/reflector defocusing and reflector gim-balling" discloses a system and method for changing the radiation pattern of an antenna assembly of a satellite in orbit. The antenna assembly includes a reflector antenna fed by a feed assembly. The reflector antenna transmits and receives signals within a radiation pattern. The reflector antenna and the feed assembly are movably mounted to a sliding mechanism so that they can be displaced with respect to one another. The displacement causes defocusing as the reflector antenna is displaced from the focus point. The defocusing causes the radiation pattern to become more compact or broadened. Thus, the radiation pattern of the satellite provided with a single reflector antenna and a single feed element may be changed while the satellite is in orbit.

[0008] EP 0 854 590 entitled "Analog processor for digital satellites" discloses an analog processor for use with digital satellites. This analog pre-processor includes a digital regenerative repeater, including at least one antenna having a plurality of receive elements, a beamformer for modifying the characteristics of the signals from the receive elements in some fashion, receivers, and a downconversion stage which is compatible with an NxM switching matrix. In the NxM switching matrix, any input can be routed to any of M outputs. The switching matrix is configured, and can be reconfigured, to route the incoming beams to the required number of sub-band processing chains depending on the number of carriers (i.e. the bandwidth) of the incoming uplink signal to be processed.

[0009] Each sub-band processing chain consists of a downconverter or mixer, a variable local oscillator (VLO), and a band path filter (BPF). The mixer takes as inputs one of the uplink beams from the NxM switch and a selectable frequency translation signal from a variable local oscillator. The frequency translation signal from the VLO is preferably generated by the analog pre-processor, but could be from an external source, or could be selected from a set of fixed local oscillators, supplied either internally or externally to the analog pre-processor.

[0010] The sub-band processing chains extract or segment a portion of the incoming RF uplink spectrum. In order to accomplish this functional result, the frequency translation signal from the VLO must be selectable or programmable over the bandwidth of the incoming RF signals. The frequency of the VLO is selected in order to bring the desired carriers (sub-band) into the passband of the subsequent bandpass filters.

[0011] The present invention is a communication payload that can be reconfigured in space such that it mimics many payloads with various frequency plans and antenna coverages. The combination of a flexible antenna system and an agile repeater capable of handling various uplink and downlink frequency plans makes a reconfigurable payload possible.

[0012] Three technologies are combined to make a reconfigurable payload for a satellite; a flexible coverage pattern, a variable downconverter technology, and sufficiently filtered channels across the downlink bandwidth. There are several variations to each of these three technologies, each combinable with the others.

[0013] A flexible coverage pattern can be provided by any one of the following methods: a dual reflector antenna configuration that is steerable, rotateable, and/or

defocusable used as a standalone antenna or as part of a farm of antennas, a single reflector antenna configuration that is steerable, rotateable and/or defocusable used as a stand alone or in a farm of antennas, or a reconfigurable phased array either direct radiating or reflecting off either a dual or a single antenna system.

[0014] The variable downconverter technology can be provided by any means. It is possible to use downconverters that have either local or external oscillators. The frequency is generated either by a frequency synthesizer or switching between multiple fixed oscillators of various frequencies. Another frequency selecting alternative is groups of switchable downconverters using fixed oscillators.

[0015] Channels across the downlink bandwidth can be sufficiently filtered using a sufficient number of input multiplex (IMUX) filters to channelize every channel of the potential receive spectrum. Additionally, a sufficient number of output multiplex (OMUX) filters to channelize every channel of the potential transmit spectrum is also used. A sufficient number of switches are used to access IMUX and OMUX filters, along with a method of routing channels between IMUX filters, OMUX filters, switches and high power amplifiers.

[0016] It is an object of the present invention to improve the backup capabilities of satellite systems.

[0017] It is another object of the present invention to provide a satellite payload that can be reconfigured to mimic the payload of many different satellites, thereby improving backup capabilities without the cost prohibitive option of individual backup satellites.

[0018] It is still another object of the present invention to provide a flexible antenna configuration, a selectable uplink and downlink frequency plan, and a channelized filter system to have reconfigurable payload capabilities for a satellite.

[0019] Other objects and features of the present invention will become apparent when viewed in light of the detailed description of the preferred embodiment when taken in conjunction with the attached drawings and appended claims.

FIGURE 1A is an example of a coverage pattern for four Ku-band antennas on a reconfigurable satellite of the present invention;

FIGURE 1B is an example of a different coverage pattern for four Ku-band antennas on the reconfigurable satellite of the present invention;

FIGURE 1C is an example of another coverage pattern for four Ku-band antennas on the reconfigurable satellite of the present invention;

FIGURE 2 is a block diagram of a single conversion mixer with a fixed oscillator;

FIGURE 3 is a block diagram of multiple downconverters for selectable downconversion frequencies;

FIGURE 4 is a block diagram for selectable downconversion frequency using multiple switched oscillators;

FIGURE 5 is a block diagram of multiple fixed oscillators in a dual conversion configuration;

FIGURE 6 is a block diagram of multiple oscillators to handle variable up and down conversion frequencies with a common IF;

FIGURE 7 is a block diagram of a dual conversion synthesizer topology with a common IF; and

FIGURE 8 is a block diagram of a reconfigurable payload.

[0020] Three separate technologies are utilized in one spacecraft to allow a communications payload of a satellite to be reconfigured in space such that it may mimic many payloads with various frequency plans and antenna coverages for providing backup services for failed satellites. Flexible antenna coverage, variable downconverter technology and channels sufficiently filtered across the downlink bandwidth are all necessary, in combination, to achieve reconfiguration of the satellite in space.

[0021] A typical, non-reconfigurable spacecraft has "shaped" antenna coverage. To generate the strongest received signal on the ground, a shaped coverage pattern transmits the maximum amount of the available power to the intended coverage area and the minimum amount of power to undesired areas. For example, an English language direct-to-home satellite system might broadcast to the United States and Canada while it would not transmit to adjacent ocean regions and Mexico.

[0022] The shape of the desired coverage pattern varies from satellite to satellite. A beam covering the United States varies significantly from a beam covering Japan or Europe. Even two satellites covering the same areas may require different shaped beams if they are located at two different orbital locations.

[0023] For a reconfigurable satellite to be flexible and to mimic a variety of satellites, the satellite must be able to change its coverage pattern in orbit. A broadband flexible antenna coverage is necessary in a reconfigurable spacecraft design. The broadband nature of the antenna is required so that the same antennas may receive or transmit any of the desired uplink and downlink frequencies. To the extent that the antennas are not sufficiently broadband, additional antennas will be required, (i.e. separate transmit and receive antennas). However, there is a significant increase in weight and therefore, cost associated with additional antennas.

[0024] There are several technologies available to ac-

complish this goal. For example, pointable, rotateable, defocusable antennas mounted to the nadir, or earth-facing, side of the spacecraft can be rotated, pointed and defocused to provide coverage for any desired area.

[0025] Figures 1A through 1C are examples of three such coverage patterns for four Ku-band antennas. It should be noted that while Ku-band antenna coverage is shown, it is for example purposes and the present invention can be applied to C-band and Ka-band operation as well. Figure 1A is the Atlantic Ocean Region (AOR) including the United States, Mexico, Northern South America, Southern South America and Europe. Figure 1B is the Indian Ocean Region (IOR) including Europe and the Middle East, India, Asia, and South Africa. Figure 1C is the Pacific Ocean Region (POR) including Northeast Asia, Southeast Asia, Australia and the United States. These are examples of the different shaped antenna patterns in a satellite fleet.

[0026] Other technologies may be used to accomplish the same effect. For example, reconfigurable phased array antennas or steerable spot beam antennas, or a combination are well known antenna technologies that can change their coverage patterns in orbit. In the preferred embodiment, there are six (6) antennas in the system. Two operate at C-band and four operate at Ku-band. All of the antennas are Gregorian dual-reflector antennas with a rotateable main reflector. The four Ku-band antennas also use feed defocusing which facilitates beam shape variation in orbit. The function of the antenna system is to generate beams covering the many different areas covered by existing satellites in a fleet of satellites, for example, the three ocean regions shown in Figures 1A through 1C.

[0027] A reconfigurable payload can be realized by combining a type of flexible antenna coverage technology with variable uplink and downlink frequency technologies and sufficient filtering technologies.

[0028] Variable downconverter technology is the next piece of the present invention. The frequency at which a signal is transmitted to a satellite is known as the uplink frequency. The frequency at which the signal is broadcast back down to the ground is referred to as the downlink frequency. The uplink and downlink frequencies must be different from each other to avoid interference with each other. The process of changing a signal from the uplink frequency to the corresponding downlink frequency is known as downconversion. This is because the uplink frequency is generally higher than the downlink frequency. And, for obvious reasons, in cases where the uplink frequency is lower than the downlink frequency, the process is called upconversion.

[0029] Upconverters and downconverters use an analog technology known as a mixer. A mixer takes the input of two voltage signals and outputs their product. To downconvert (or upconvert) a signal, the mixer is fed by the uplink signal and an oscillator operating at a frequency equal to the difference between the uplink and downlink frequencies. The mixer outputs the product of the frequencies equal to the desired downlink frequency.

[0030] An example of a single conversion mixer with a fixed oscillator is shown in Figure 2. The uplink signal has a frequency, f1. The downlink signal has a frequency, f2. An oscillator operates at a frequency that, when mixed with the uplink signal, produces a downlink signal f2. A wide range of oscillator frequencies are used by satellites to perform up and down conversions. Therefore, a satellite attempting to mimic the operating of existing or future satellites must be able to mimic the frequencies of the oscillators on board any one of many satellites.

[0031] Typically, on a satellite, the device containing the mixer is inside a box known as either a downconverter, or if a low noise amplifier is also inside the box, it is known as a receiver. In both cases, the oscillator may be either internal or external to the box. When the oscillator is internal to the box, it is called a local oscillator. Local oscillators are typically generated by the use of crystals operating at precise predetermined frequencies

[0032] There are a several technologies available that generate a variety of frequencies. One way is to switch between a variety of up and down converters, each with its own local oscillator, or to use an up (or down) converter fed by a variety of switchable oscillators each operating at a different frequency. An example of this arrangement is shown in Figure 3.

[0033] There is shown in Figure 3 an uplink signal having a frequency f1, a switch S1 selects between a first mixer, M1 and a second mixer, M2. A second switch S2 selects between the mixers M1 and M2 and outputs the desired downlink frequency. Each of the mixers M1 and M2 is connected to an independent oscillator 10 and 12 having fixed frequencies. The first oscillator 10 is connected to the mixer M1 and operates at a frequency of f2-f1. The second oscillator 12 is connected to the second mixer, M2 and operates at a frequency f3-f1.

[0034] Depending on which switch path is selected, the downlink frequency can be selected as either f2 or f3. When switch S1 is selected, the output of the mixer is the downlink frequency f2 and when switch S2 is selected the output of the mixer is the downlink frequency f3. Obviously, the complexity of the switching system depends on the number of switches, mixers and oscillators and can be modified as necessary.

[0035] An alternative method is to use a down (or up) converter fed by a variety of switchable oscillators each operating at a different frequency. An example of this arrangement is shown in Figure 4. The uplink signal is operating at frequency f1 and is fed into a mixer M1 that produces the downlink signal. A switch, S1, allows desired frequencies to be selected from multiple oscillators. In the Figure 4 example, two independent oscillators are shown 12 and 14, each operating at a different frequency. Oscillator 12 operates at a frequency f2-f1

and oscillator 14 operates at a frequency of f3-f1. Therefore, depending on which oscillator is selected by switch S1 and mixed with uplink frequency f1 in mixer M1, the downlink frequency will be f2 or f3. It is to be understood that any number of oscillators may be employed.

[0036] In the configuration shown in Figure 4, there is the potential for in-band spurious signals to degrade the quality of the communication signal. A spurious signal, also called a spur, is an undesired tone generated by the non-linear properties inherent to mixers. The severity of a spur is a function of the signal and local oscillator frequencies. There is an alternative method to downconvert, without the drawback of spurs. A dual conversion design eliminates spurs by first downconverting the signal to an intermediate frequency (IF) and then performing a second conversion to the desired downlink frequency.

[0037] The output of the mixer is a product of frequencies, which also includes a product of harmonics of those frequencies. These harmonics, or spurs, may be close in frequency to the desired signal making it difficult to filter out the undesired frequencies. Carefully selecting an intermediate frequency will avoid interference from potential harmonics the sums and differences of the receive and local oscillator signals that are near the desired downlink signal.

[0038] Figure 5 is a block diagram of a downconverter having multiple fixed oscillators in a dual conversion configuration to select different downlink frequencies from the same downconverter without the potential for spurs by using an intermediate frequency (IF). The arrangement is similar to the one shown in Figure 4. However, there is an additional mixer M2 and an oscillator 16 operating at a frequency that, when mixed with the uplink frequency f1 will output a predetermined intermediate frequency (IF). The intermediate frequency (IF) is mixed with the signal from either oscillator 12 having a frequency of f2-IF or oscillator 14 having a frequency of f3-If to output the downlink frequency either f2 or f3.

[0039] In some applications it is necessary to handle different uplink and downlink frequencies on the same downconverter. The dual conversion arrangement can be modified such that the oscillator that mixes with the uplink signal can also vary. Figure 6 is an example of multiple oscillators to handle variable up and down conversion frequencies with a common intermediate frequency. The uplink signal has a variable frequency, f1 or f2. The uplink signal is mixed, by mixer M1, with an intermediate frequency (IF), fed by one of two oscillators 18 or 20 and a switch S1 to select between the oscillators 18 and 20. The uplink signal is then converted to the intermediate frequency (IF). Another mixer M2 mixes the intermediate frequency (IF) with a signal from one of a plurality of oscillators 22 and 24, selectable by switch S2. In the example shown in Figure 6, the oscillators 22 and 24 operate at frequencies f3-IF and f4-IF respectively. The result is a variable down link signal, in the example shown either f3 or f4. While only four oscillators are shown in the present example, it is to be understood that any number of oscillators is possible, resulting in any number of possible output frequencies.

[0040] Multiple oscillators are one way to generate multiple downconversion frequencies. An alternative to multiple oscillators is the use of synthesizers. Synthesizers generate an arbitrary frequency within a specified range of frequencies and fixed step size. Therefore, a single synthesizer can replace a single, or many oscillators. Figure 7 is a block diagram of this arrangement.

[0041] The system has an uplink signal having a frequency u1, u2, u3, etc. A synthesizer 26 produces a signal u1-IF, u2-IF, u3-IF, etc and is mixed with the uplink signal by mixer M1. The uplink signal is now converted to the intermediate frequency IF. The intermediate frequency IF is mixed in mixer M2 with a signal from another synthesizer 28 that is capable of generating a signal d1-IF, d2-IF, d3-IF, etc. The output of mixer M2 is the downlink signal d1, d2, d3, etc. In Figures 4 through 7 the intermediate frequency was assumed to be lower than the receive frequency for the purpose of illustration. In practice, the intermediate frequency (IF) may be higher or lower than the receive frequency as long as the resulting intermediate frequency (IF) yields a spur free region to translate to the final desired output frequency. Either approach may be used.

[0042] The last piece of the present invention lies in proper filter technologies. In order to accommodate operation in a wide portion of the allocated spacecraft transmit spectrum, input and output channel filters are required for each possible broadcast channel. It is possible to select filters that cover the entire bandwidth contiguously. This provides the most efficient scenario. Figure 8 is a block diagram of a repeater for a reconfigurable satellite of the present invention, and can be used to explain the filtering technology.

[0043] The input channel filters 40, or IMUX, separate the wideband uplink signal into multiple channels. The signals are low power, and losses are not a major concern at low power levels. Therefore, these filters are easily selectable. In operation the signal is passed through each channel where a passband of the filter selects and routes the proper signal. All other signals are reflected back into a circulator and passed onto the next channel filter.

[0044] The output channel filters 48, or OMUX, combine amplified signals and route the signal to the antenna. The output channel filters are high power. The number of channels should be limited to approximately twenty (20) adjacent channels for practical purposes. Theoretically, there is no limit to the number of contiguous OMUX filters, but for practical design considerations, the number should be limited until current the current state of the art is enhanced enough to make more channels cost effective. OMUX filters deal with signals that are at very high power levels. High power results in the generation of heat and the must be dissipated. Additionally, operating at high power means that losses be-

come more critical.

[0045] In the preferred embodiment, to accommodate more channels using existing technology and still avoid excessive heat and losses while maintaining realistic costs, it is necessary to combine multichannel continuous OMUX filters with diplexed groups of contiguous OMUX filters. Gaps must be present in the diplexed frequency region in order for minimum insertion losses. It is also possible to include tunable filters or high/low pass filters as alternatives to diplexers. In the future there may be technology that allows contiguous filters with more channels that will simplify the present invention.

[0046] It may not always be desirable for the satellite to operate near the full number of possible channels in a given configuration. In such cases, there will be more filters than active channels. A reduced number of active channels permits fewer high power amplifiers to be implemented in the payload. A switching system 42 and 46 that allows different amplifiers to be switched to and from different filters depending the desired satellite configuration is incorporated. High power microwave switches make it possible to use the same high power amplifier with multiple filters. The routing from switches to amplifiers and filters is accomplished with either coaxial cables or waveguide.

[0047] Referring to figure 8 in detail, there is shown a block diagram of one embodiment of a repeater for the reconfigurable satellite of the present invention. The example diagram in figure 8 is capable of mimicking any one of six satellites in a fleet of satellites. It should be noted that while this example of backing up any one of six satellites is shown, the present invention can be applied to mimic any number of satellites, or can be used as a stand alone satellite for in-orbit flexibility.

[0048] Section I of Figure 8 establishes the repeater noise figure, converts signals from the receive band to the transmit band and provides a substantial portion of the repeater gain. In the present example, Section I accepts input signals at eight antenna ports 30. The signals are routed through low noise amplifiers 32 to a network 34 which combines the received beams in any desired combination for the flexible antenna coverage discussed above. Downconverters 36 handle various frequencies and can perform any one of six conversions required by a satellite fleet of six satellites and provide the variable downconversion discussed above.

[0049] Section II accepts the signal sets from Section I and divides them into channelized portions using input multiplexer filters. This is done by a set of switches 38 that route the various Section I outputs to the appropriate input filters 40. After filtering, the channelized signals, which can be up to thirty-six (36) channels, are routed through a traveling wave tube (TWT) input redundancy ring. Each box in the block diagram represents six (6) input filters 40. A total of ninety-six (96) input filters are used to provide the required frequency plan flexibility. The channelized output signals are routed through another set of switches 42 to Section III.

[0050] Section III provides the channelized gain control, TWT linearization, and amplification to the TWT output levels of 140 Watts. An equalization network (not shown) may also be included with each TWT to equalize its frequency response over the transmit bandwidth. This permits broadband linearization of the TWT's. Each box in Section III represents a set of six active TWT's with linearizers, or high power amplifiers, 44, also known as OMUX filters.

[0051] Section IV accepts the amplified output signals from the TWT's and routes them through the output portion of the redundancy ring to the output multiplexer selection switches 46. These switches 46 are used to configure the repeater to emulate any of the six satellites in the fleet. The switches access up to four multiplexers for each polarization. Each output multiplexer box represents six (6) output filters 48. A total of one hundred fifty-six (156) output filters 48 are used in the output multiplexers to achieve the versatility in the frequency spectrum. The section IV outputs are connected to transmit antennas 50.

[0052] The combination of the flexible antenna system, the variable downlink conversion system and the selectable filter technology allow a single satellite to be reconfigured to mimic any other satellite in a fleet of satellites. This allows a single satellite to provide backup for any one satellite that may fail in fleet. The reconfigurable satellite of the present invention provides backup coverage without having to interrupt service and force users to use alternative satellite operators to continue their service. The backup coverage provided by the reconfigurable satellite of the present invention is accomplished with minimal interruption of service and without the impractical expense of having a unique spare for each satellite of a fleet.

[0053] While particular embodiments of the invention have been shown and described, numerous variations and alternate embodiments will occur to those skilled in the art. Accordingly, it is intended that the invention be limited only in terms of the appended claims.

Claims

1. A reconfigurable satellite for modifying predetermined characteristics of a payload, the reconfigurable satellite comprising:

   an antenna system (50) having a flexible coverage pattern;
   a variable signal converter system (36) for converting a first predetermined frequency (f_1; f_2; u_1; u_2; u_3) to a second predetermined frequency (f_2; f_3; f_4; d_1; d_2; d_3); and
   filter means (38-48) for isolating selected input and output channels;

   whereby the predetermined characteristics of

the payload can be modified by changing the flexible coverage pattern, varying the first and second predetermined frequencies and filtering the input and output channels while the satellite is in orbit, wherein the modified predetermined characteristics of the payload mimic predetermined characteristics of a failed satellite such that the reconfigurable satellite provides a backup means for the failed satellite with minimal interruption in satellite service.

2. The satellite of claim 1, wherein the antenna system (50) further comprises a dual reflector antenna that is steerable, rotatable and/or defocusable.

3. The satellite of any of claims 1 or 2, wherein the variable signal converter system (36) further comprises:

a plurality of oscillators (12, 14; 22, 24) each operating at a different predetermined frequency equal to the difference between a first predetermined frequency and a second predetermined frequency;
a first mixer (M1; M2) connected to each of the plurality of oscillators (12, 14; 22, 24) for mixing the first predetermined frequency with one of the different predetermined frequencies of the plurality of oscillators (12, 14; 22, 24);
a switch (S1; S2) connected between the first mixer (M1; M2) and each of the pluralities of oscillators (12, 14; 22, 24), the switch (S1; S2) for selecting one of the plurality of oscillators (12, 14; 22, 24);

whereby the mixer (M1; M2) produces an output equal to the second predetermined frequency.

4. The satellite of any of claims 1 or 2, wherein the variable signal converter system (36) further comprises:

the first predetermined frequency being one of a plurality of frequencies (u_1, u_2, u_3);
a first synthesizer (26) for generating an output to be mixed with the plurality of first predetermined frequencies (u_1, u_2, u_3);
a first mixer (M1) connected between the plurality of first predetermined frequencies (u_1, u_2, u_3) and the first synthesizer (26) for mixing the plurality of first predetermined frequencies (u_1, u_2, u_3) with the output of the first synthesizer (26) to produce an intermediate frequency (IF);
a second synthesizer (28) for generating an output to be mixed with the intermediate frequency (IF);
a second mixer (M2) for mixing the intermediate frequency (IF) and the output of the second synthesizer (28) to produce a plurality of second predetermined frequencies (d_1, d_2, d_2).

5. The satellite of any of claims 1 to 4, wherein the filter means (38-48) further comprises:

a network (38) of switches for rooting a signal through the input channels;
a plurality of input multiplexer filters (40) selected by the network (38) of switches for channelizing the input channels;
a network (42) of switches for rooting the signal from the input multiplexer filters (40) to a plurality of output multiplexer filters (44);
a network (46) of switches that accepts an output signal from the plurality of output multiplexer filters (44) and reconfigures the payload.

6. The satellite of any of claims 2 to 5, wherein the dual reflector antenna is a standalone antenna.

7. The satellite of any of claims 2 to 5, wherein the dual reflector antenna is used in a farm of antennas.

8. The satellite of any of claims 3 to 7, wherein the variable signal converter system (36) further comprises:

an oscillator (16; 18, 20) operating at a different predetermined frequency (IF-f_1; IF-f_1, IF-f_2) to be mixed with the first predetermined frequency (f_1; f_1, f_2);
a second mixer (M2; M1) connected to the oscillator (16; 18, 20) for mixing the first predetermined frequency (f_1; f_1, f_2) and the different predetermined frequency (IF-f_1; IF-f_1, IF-f_2) and output an intermediate frequency (IF);

whereby the intermediate frequency (IF) is mixed with one of the frequencies of the plurality of oscillators (12, 14; 22, 24) to produce the second predetermined frequency (f_2, f_3; f_3, f_4).

9. The satellite of claim 8, wherein the variable signal converter system (36) further comprises:

a plurality of oscillators (18, 20) each operating at a different predetermined frequency (IF-f_1, IF-f_2) to be mixed at the second mixer (M1) with the first predetermined frequency (f_1, f_2);
a switch (S1) connected to each of the plurality of oscillators (18, 20) and the second mixer (M1) for selecting one of the plurality of oscillators (18, 20);

whereby the second mixer (M1) produces an output equal to the intermediate frequency (IF).

Patentansprüche

1. Rekonfigurierbarer Satellit zum Modifizieren vorgegebener Eigenschaften einer Nutzlast, wobei der rekonfigurierbare Satellit aufweist:

   ein Antennensystem (50) mit einem flexiblen Überdeckungsmuster;
   ein variables Signalumwandlungssystem (36) zum Umwandeln einer ersten vorgegebenen Frequenz (f_1; f_2; u_1; u_2; u_3) zu einer zweiten vorgegebenen Frequenz (f_2; f_3; f_4; d_1; d_2; d_3); und
   Filtermittel (38-48) zum Isolieren ausgewählter Eingangs- und Ausgangskanäle;

   wobei die vorgegebenen Eigenschaften der Nutzlast modifiziert werden können, indem das flexible Überdeckungsmuster geändert wird, die erste und die zweite vorgegebene Frequenz geändert werden und die Eingangs- und Ausgangskanäle gefiltert werden, während sich der Satellit in einer Umlaufbahn befindet, wobei die modifizierten vorgegebenen Eigenschaften der Nutzlast vorgegebene Eigenschaften eines ausgefallenen Satelliten simulieren, so dass der rekonfigurierbare Satellit ein Sicherungsmittel für den ausgefallenen Satelliten mit einer minimalen Unterbrechung eines Satellitendienstes bereitstellt.

2. Satellit nach Anspruch 1, wobei das Antennensystem (50) des weiteren eine Doppelspiegelantenne aufweist, die lenkbar, drehbar und/oder die defokussierbar ist.

3. Satellit nach einem der Ansprüche 1 oder 2, wobei das variable Signalumwandlungssystem (36) des weiteren aufweist:

   eine Vielzahl von Oszillatoren (12, 14; 22, 24), wobei jeder bei einer anderen vorgegebenen Frequenz betrieblich ist, die gleich der Differenz zwischen einer ersten vorgegebenen Frequenz und einer zweiten vorgegebenen Frequenz ist;
   eine erste Mischeinrichtung (M1; M2), die mit jedem Oszillator der Vielzahl von Oszillatoren (12, 14; 22, 24) zum Mischen der ersten vorgegebenen Frequenz mit einer der anderen vorgegebenen Frequenzen der Vielzahl von Oszillatoren (12, 14; 22, 24) verbunden ist;
   einen Schalter (S1; S2), der zwischen der ersten Mischeinrichtung (M1; M2) und jedem Oszillator der Vielzahl von Oszillatoren (12, 14; 22, 24) verbunden ist, wobei der Schalter (S1; S2) zum Auswählen eines Oszillators der Vielzahl von Oszillatoren (12, 14; 22, 24) dient;

   durch welche die Mischeinrichtung (M1; M2) eine Ausgabe erzeugt, die gleich der zweiten vorgegebenen Frequenz ist.

4. Satellit nach einem der Ansprüche 1 oder 2, wobei das variable Signalumwandlungssystem (36) des weiteren aufweist:

   wobei die erste vorgegebene Frequenz eine Frequenz aus einer Vielzahl von Frequenzen (u_1, u_2, u_3) ist;
   einen ersten Synthesizer (26) zum Erzeugen einer Ausgabe, die mit der Vielzahl des ersten vorgegebenen Frequenzen (u_1, u_2, u_3) gemischt werden soll;
   eine erste Mischeinrichtung (M1), die zwischen der Vielzahl der ersten vorgegebenen Frequenzen (u_1, u_2, u_3) und dem ersten Synthesizer (26) zum Mischen der Vielzahl der ersten vorgegebenen Frequenzen (u_1, u_2, u_3) mit der Ausgabe des ersten Synthesizers (26) verbunden ist, um eine Zwischenfrequenz (IF) zu erzeugen;
   einen zweiten Synthesizer (28) zum Erzeugen einer Ausgabe, die mit der Zwischenfrequenz (IF) gemischt werden soll;
   eine zweite Mischeinrichtung (M2) zum Mischen der Zwischenfrequenz (IF) und der Ausgabe des zweiten Synthesizers (28), um eine Vielzahl zweiter vorgegebener Frequenzen (d_1, d_2, d_3) zu erzeugen.

5. Satellit nach einem der Ansprüche 1 bis 4, wobei die Filtermittel (38-48) des weiteren aufweisen:

   ein Netzwerk (38) von Schaltern zum Leiten eines Signals durch die Eingangskanäle hindurch;
   eine Vielzahl von Eingangsmultiplexerfiltern (40), die durch das Netzwerk (38) von Schaltern zum Kanalisieren der Eingangskanäle ausgewählt sind;
   ein Netzwerk (42) von Schaltern zum Leiten des Signals von den Eingangsmultiplexerfiltern (40) zu einer Vielzahl von Ausgangsmultiplexerfiltern (44);
   ein Netzwerk (46) von Schaltern, das ein Ausgangssignal der Vielzahl von Ausgangsmultiplexerfiltern (44) akzeptiert und die Nutzlast rekonfiguriert.

6. Satellit nach einem der Ansprüche 2 bis 5, wobei die Doppelspiegelantenne eine selbständige Antenne ist.

7. Satellit nach einem der Ansprüche 2 bis 5, wobei die Doppelspiegelantenne in eine Antennenfarm verwendet wird.

8. Satellit nach einem der Ansprüche 3 bis 7, wobei das variable Signalumwandlungssystem (36) des weiteren aufweist:

einen Oszillator (16; 18, 20), der bei einer anderen vorgegebenen Frequenz (IF-f_1; IF-f_1, IF-f_2) betrieblich ist, die mit der ersten vorgegebenen Frequenz (f_1; f_1, f_2) gemischt werden soll;
eine zweite Mischeinrichtung (M2; M1), die mit dem Oszillator (16; 18, 20) zum Mischen der ersten vorgegebenen Frequenz (f_1; f_1, f_2) und der anderen vorgegebenen Frequenz (IFf_1; IF-f_1, IF-f_2) verbunden ist und eine Zwischenfrequenz (IF) ausgibt;
wodurch die Zwischenfrequenz (IF) mit einer der Frequenzen der Vielzahl von Oszillatoren (12, 14; 22, 24) gemischt wird, um die zweite vorgegebene Frequenz (f_2, f_3; f_3, f_4) zu erzeugen.

9. Satellit nach Anspruch 8, wobei das variable Signalumwandlungssystem (36) des weiteren aufweist:

eine Vielzahl von Oszillatoren (18, 20), wobei jeder bei einer anderen vorgegebenen Frequenz (IF-f_1, IF-f_2) betrieblich ist, die bei der zweiten Mischeinrichtung (M1) mit der ersten vorgegebenen Frequenz (f_1, f_2) gemischt werden soll;
einen Schalter (S1), der mit jedem der Vielzahl von Oszillatoren (18, 20) und der zweiten Mischeinrichtung (M1) zum Auswählen eines Oszillators der Vielzahl von Oszillatoren (18, 20) verbunden ist;

wodurch die zweite Mischeinrichtung (M1) eine Ausgabe erzeugt, die gleich der Zwischenfrequenz (IF) ist.

Revendications

1. Satellite reconfigurable servant à modifier des caractéristiques prédéterminées d'une charge utile, le satellite reconfigurable comprenant :

un système d'antenne (50) ayant un diagramme de couverture flexible ;
un système convertisseur de signaux variable (36) servant à convertir une première fréquence prédéterminée (f_1, f_2, u_1, u_2, u_3) en une deuxième fréquence prédéterminée (f_2, f_3, f_4, d_1, d_2, d_3) ; et
un moyen de filtrage (38 à 48) servant à isoler des canaux d'entrée et de sortie sélectionnés ;
ce par quoi les caractéristiques prédéterminées de la charge utile peuvent être modifiées en changeant le diagramme de couverture flexible, en faisant varier les première et deuxième fréquences prédéterminées et en filtrant les canaux d'entrée et de sortie pendant que le satellite est en orbite, dans lequel les caractéristiques prédéterminées modifiées de la charge utile imitent des caractéristiques prédéterminées d'un satellite tombé en panne de sorte que le satellite reconfigurable fournit un moyen de sauvegarde pour le satellite tombé en panne avec une interruption minimale dans le service du satellite.

2. Satellite selon la revendication 1, dans lequel le système d'antenne (50) comprend en outre une antenne à double réflecteur qui peut être orientée, tournée et/ou défocalisée.

3. Satellite selon l'une quelconque des revendications 1 ou 2, dans lequel le système convertisseur de signaux variable (36) comprend en outre :

une pluralité d'oscillateurs (12, 14 ; 22, 24), chacun fonctionnant à une fréquence prédéterminée différente égale à la différence entre une première fréquence prédéterminée et une deuxième fréquence prédéterminée ;
un premier mélangeur (M1 ; M2) connecté à chacun des oscillateurs parmi la pluralité d'oscillateurs (12, 14 ; 22, 24) servant à mélanger la première fréquence prédéterminée avec l'une des fréquences prédéterminées différentes de la pluralité d'oscillateurs (12, 14 ; 22, 24) ;
un commutateur (S1 ; S2) connecté entre le premier mélangeur (M1 ; M2) et chacun des oscillateurs parmi la pluralité d'oscillateurs (12, 14 ; 22, 24), le commutateur (S1 ; S2) servant à sélectionner un oscillateur parmi la pluralité d'oscillateurs (12, 14 ; 22, 24) ;
ce par quoi le mélangeur (M1 ; M2) produit une sortie égale à la deuxième fréquence prédéterminée.

4. Satellite selon l'une quelconque des revendications 1 ou 2, dans lequel le système convertisseur de signaux variable (36) comprend en outre :

la première fréquence prédéterminée qui est l'une des fréquences parmi la pluralité de fréquences (u_1, u_2, u_3) ;
un premier synthétiseur (26) servant à générer une sortie à mélanger avec la pluralité de premières fréquences prédéterminées (u_1, u_2, u_3) ;
un premier mélangeur (M1) connecté entre la pluralité de premières fréquences prédéterminées (u_1, u_2, u_3) et le premier synthétiseur (26) servant à mélanger la pluralité de premières

fréquences prédéterminées (u_1, u_2, u_3) à la sortie du premier synthétiseur (26) pour produire une fréquence intermédiaire (FI) ;
un deuxième synthétiseur (28) servant à générer une sortie à mélanger avec la fréquence intermédiaire (FI);
un deuxième mélangeur (M2) servant à mélanger la fréquence intermédiaire (FI) et la sortie du deuxième synthétiseur (28) pour produire une pluralité de deuxièmes fréquences prédéterminées (d_1, d_2, d_3).

5. Satellite selon l'une quelconque des revendications 1 à 4, dans lequel le moyen de filtrage (38 à 48) comprend en outre :

un réseau (38) de commutateurs servant à acheminer un signal par les canaux d'entrée ;
une pluralité de filtres multiplexeurs d'entrée (40) sélectionnés par le réseau (38) de commutateurs servant à multiplexer les canaux d'entrée ;
un réseau (42) de commutateurs servant à acheminer le signal des filtres multiplexeurs d'entrée (40) à une pluralité de filtres multiplexeurs de sortie (44);
un réseau (46) de commutateurs qui accepte un signal de sortie provenant de la pluralité de filtres multiplexeurs de sortie (44) et qui reconfigure la charge utile.

6. Satellite selon l'une quelconque des revendications 2 à 5, dans lequel l'antenne à double réflecteur est une antenne autonome.

7. Satellite selon l'une quelconque des revendications 2 à 5, dans lequel l'antenne à double réflecteur est utilisée dans un ensemble d'antennes.

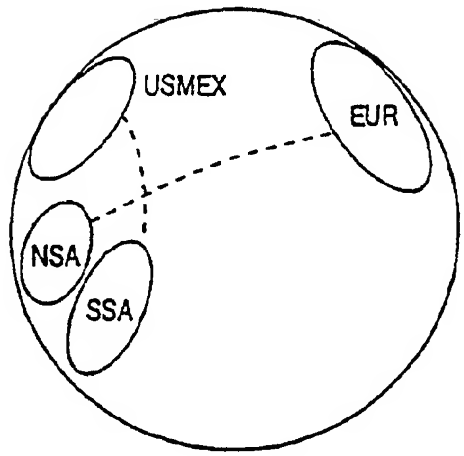
8. Satellite selon l'une quelconque des revendications 3 à 7, dans lequel le système convertisseur de signaux variable (36) comprend en outre :

un oscillateur (16 ; 18 ; 20) fonctionnant à une fréquence prédéterminée différente (FI-f_1 ; FI-f_1, FI-f_2) à mélanger à la première fréquence prédéterminée (f_1 ; f_1, f_2) ;
un deuxième mélangeur (M1; M2) connecté à l'oscillateur (16 ; 18 ; 20) servant à mélanger la première fréquence prédéterminée (f_1 ; f_1, f_2) et la fréquence prédéterminée différente (FI-f_1 ; FI-f_1, FI-f_2) et sortir une fréquence intermédiaire (FI) ;

ce par quoi la fréquence intermédiaire (FI) est mélangée (M1 ; M2) avec l'une des fréquences de la pluralité d'oscillateurs (12, 14 ; 22, 24) pour produire la deuxième fréquence prédéterminée (f_2, f_3; f_3, f_4).

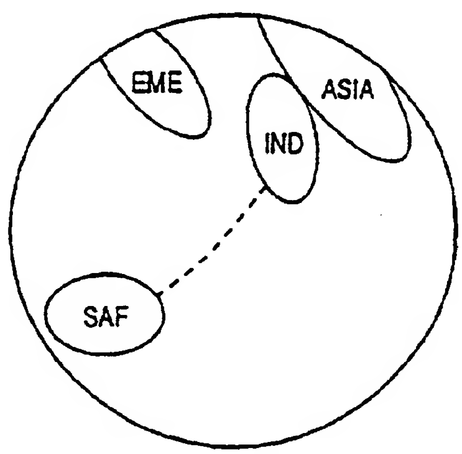
9. Satellite selon la revendication 8, dans lequel le système convertisseur de signaux variable (36) comprend en outre :

une pluralité d'oscillateurs (18, 20), chacun fonctionnant à une fréquence prédéterminée différente (FI-f_1, FI-f_2) à mélanger au deuxième mélangeur (M1) avec la première fréquence prédéterminée (f_1, f_2) ;
un commutateur (S1) connecté à chacun des oscillateurs parmi la pluralité d'oscillateurs (18, 20) et au deuxième mélangeur (M1) pour sélectionner l'un des oscillateurs parmi la pluralité d'oscillateurs (18, 20) ;
ce par quoi le deuxième mélangeur (M1) produit une sortie égale à la fréquence intermédiaire (FI).



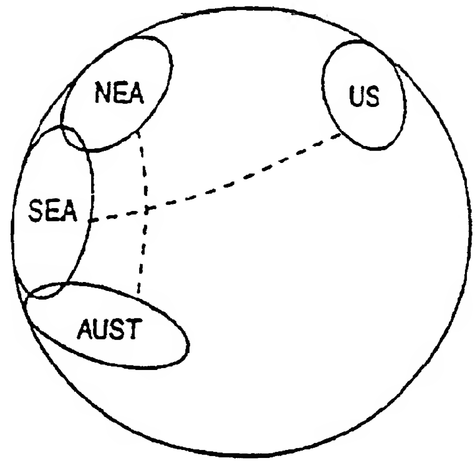
AOR	USMEX	UNITED STATES AND MEXICO
	NSA	NORTHERN SOUTH AMERICA
	SSA	SOUTHERN SOUTH AMERICA
	EUR	EUROPE

FIG. 1A



IOR	EME	EUROPE AND MID EAST
	IND	INDIA
	ASIA	ASIA
	SAF	SOUTH AFRICA

FIG. 1B



POR	NEA	NORTHEAST ASIA
	SEA	SOUTHEAST ASIA
	AUST	AUSTRALIA
	US	UNITED STATES

FIG. 1C

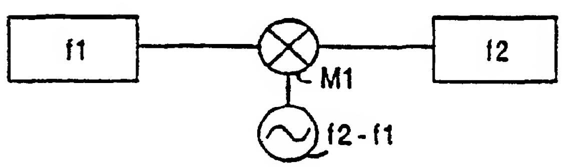


FIG. 2

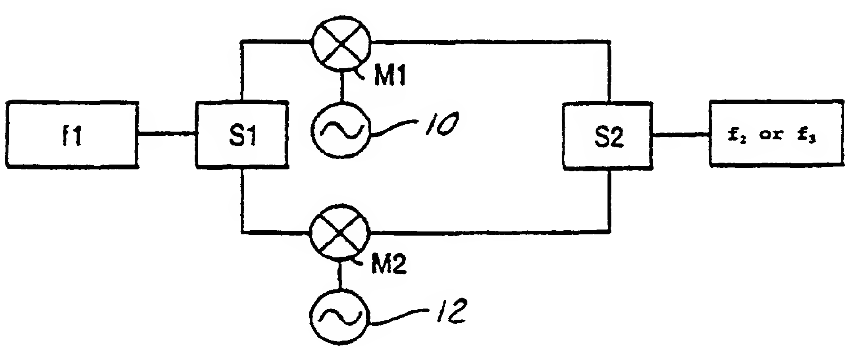


FIG. 3

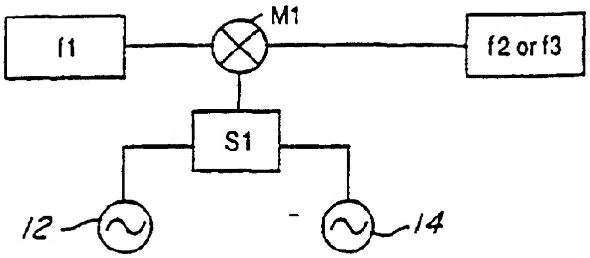


FIG. 4

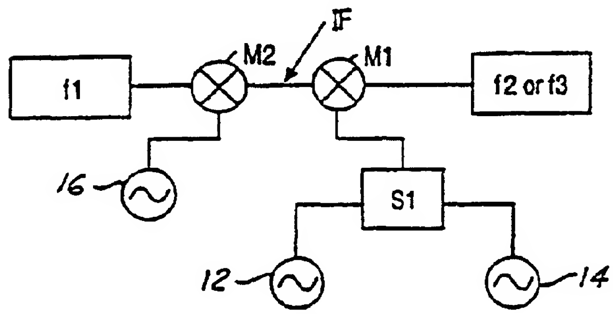


FIG. 5

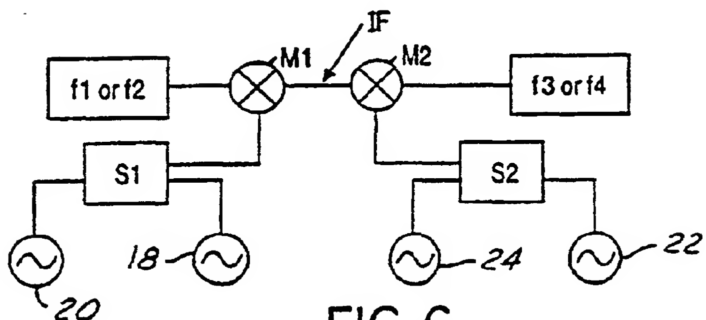


FIG. 6

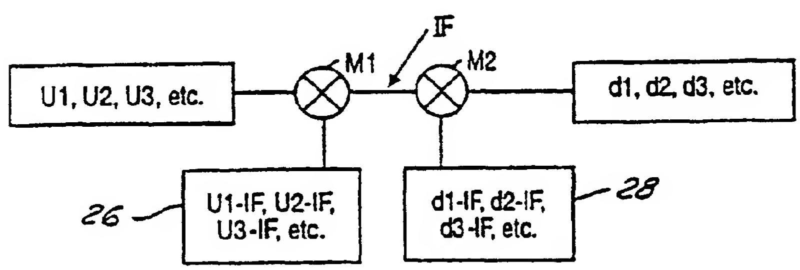


FIG. 7

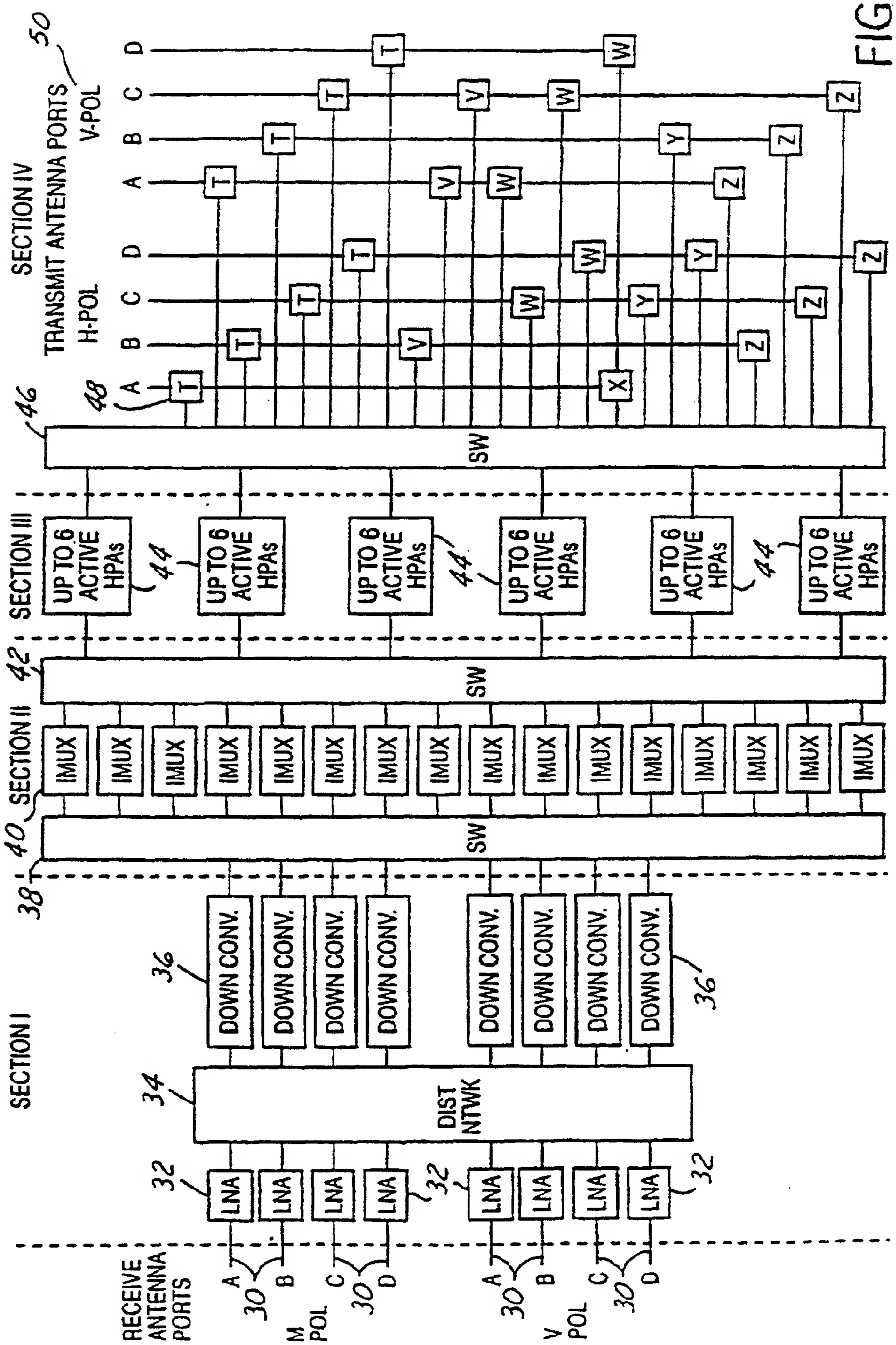

RECEIVE ANTENNA PORTS
A
B
C
D
30
H POL
V POL
LNA
32
DIST NTWK
34
DOWN CONV.
36
38
SECTION I
SW
40
SECTION II
IMUX
42
SECTION III
UP TO 6 ACTIVE HPAs
44
46
48
SECTION IV
TRANSMIT ANTENNA PORTS
H-POL
V-POL
50
T
V
W
X
Y
Z

FIG.8